

TENT COOPERATION TRE Y

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NOTIFICATION OF ELECTION

(PCT Rule 61.2)

From the INTERNATIONAL BUREAU

To:

Assistant Commissioner for Patents
United States Patent and Trademark
Office
Box PCT
Washington, D.C.20231
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 13 April 2000 (13.04.00)	
International application No. PCT/GB99/01594	Applicant's or agent's file reference P/61453.WOP/EO
International filing date (day/month/year) 20 May 1999 (20.05.99)	Priority date (day/month/year) 29 August 1998 (29.08.98)
Applicant SPENCER, Simon, Howard	

1. The designated Office is hereby notified of its election made:

☒ in the demand filed with the International Preliminary Examining Authority on:
07 March 2000 (07.03.00)

☐ in a notice effecting later election filed with the International Bureau on:

2. The election ☒ was

☐ was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland Facsimile No.: (41-22) 740.14.35	Authorized officer Olivia RANAIVOJAONA Telephone No.: (41-22) 338.83.38
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PATENT COOPERATION TREATY

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INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference P/61453.WOP/E0	FOR FURTHER ACTION see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. PCT/GB 99/ 01594	International filing date (day/month/year) 20/05/1999	(Earliest) Priority Date (day/month/year) 29/08/1998
Applicant MARCONI ELECTRONIC SYSTEMS LIMITED et al.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.
☒ It is also accompanied by a copy of each prior art document cited in this report.

1. Basis of the report

- a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.
- ☐ the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).
- b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing:
- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

2. ☐ **Certain claims were found unsearchable** (See Box I).

3. ☐ **Unity of invention is lacking** (see Box II).

4. With regard to the **title**,

- ☒ the text is approved as submitted by the applicant.
- ☐ the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

- ☒ the text is approved as submitted by the applicant.
- ☐ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No.

- ☒ as suggested by the applicant.
- ☐ because the applicant failed to suggest a figure.
- ☐ because this figure better characterizes the invention.

6

☐ None of the figures.

INTERNATIONAL SEARCH REPORT

International Application No

T/GB 99/01594

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 H04N9/04 H04N5/20 H04N5/235

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 H04N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 3 772 552 A (KUBOTA Y) 13 November 1973 (1973-11-13) column 3, line 18 - column 7, line 15 ---	1-4, 6, 7, 9, 11, 13-15, 17
Y	PATENT ABSTRACTS OF JAPAN vol. 095, no. 008, 29 September 1995 (1995-09-29) & JP 07 131708 A (CANON INC), 19 May 1995 (1995-05-19) abstract & US 5 801 773 A ---	1, 14, 17
Y	GB 2 318 012 A (MARCONI GEC LTD) 8 April 1998 (1998-04-08) cited in the application page 9, line 3 - page 20 --- -/-	2-4, 6, 7, 9, 11, 13, 15



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

° Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

23 July 1999

Date of mailing of the international search report

02/08/1999

Name and mailing address of the ISA

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Authorized officer

Materne, A

INTERNATIONAL SEARCH REPORT

International Application No

T/GB 99/01594

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 94 18801 A (SIGHT INC I) 18 August 1994 (1994-08-18) page 4, line 10 - page 32 -----	1-17

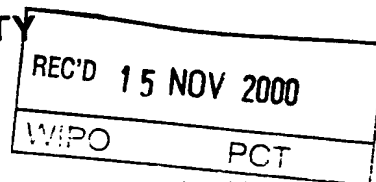
INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

T/GB 99/01594

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
US 3772552	A	13-11-1973	NONE		
JP 07131708	A	19-05-1995	US	5801773 A	01-09-1998
GB 2318012	A	08-04-1998	EP	0835030 A	08-04-1998
			JP	10200905 A	31-07-1998
WO 9418801	A	18-08-1994	EP	0739571 A	30-10-1996



INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference P/61453/EO	FOR FURTHER ACTION See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. PCT/GB99/01594	International filing date (day/month/year) 20/05/1999	Priority date (day/month/year) 29/08/1998
International Patent Classification (IPC) or national classification and IPC H04N9/04		
Applicant MARCONI ELECTRONIC SYSTEMS LIMITED et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.



2. This REPORT consists of a total of 7 sheets, including this cover sheet.

- ☐ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consist of a total of sheets.

3. This report contains indications relating to the following items:

- I ☒ Basis of the report
- II ☐ Priority
- III ☒ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV ☐ Lack of unity of invention
- V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI ☐ Certain documents cited
- VII ☒ Certain defects in the international application
- VIII ☒ Certain observations on the international application

Date of submission of the demand 07/03/2000	Date of completion of this report 13.11.2000
Name and mailing address of the international preliminary examining authority:  European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Montanari, M Telephone No. +49 89 2399 2602 

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/GB99/01594

I. Basis of the report

1. This report has been drawn on the basis of *(substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments (Rules 70.16 and 70.17).):*

Description, pages:

1-15 as originally filed

Claims, No.:

1-17 as originally filed

Drawings, sheets:

1/3-3/3 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT**

International application No. PCT/GB99/01594

☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

III. Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

The questions whether the claimed invention appears to be novel, to involve an inventive step (to be non-obvious), or to be industrially applicable have not been examined in respect of:

☐ the entire international application.

☒ claims Nos. 16.

because:

☐ the said international application, or the said claims Nos. relate to the following subject matter which does not require an international preliminary examination (*specify*):

☒ the description, claims or drawings (*indicate particular elements below*) or said claims Nos. 16 are so unclear that no meaningful opinion could be formed (*specify*):
see separate sheet

☐ the claims, or said claims Nos. are so inadequately supported by the description that no meaningful opinion could be formed.

☐ no international search report has been established for the said claims Nos. .

2. A meaningful international preliminary examination report cannot be carried out due to the failure of the nucleotide and/or amino acid sequence listing to comply with the standard provided for in Annex C of the Administrative Instructions:

☐ the written form has not been furnished or does not comply with the standard.

☐ the computer readable form has not been furnished or does not comply with the standard.

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)

Yes: Claims 2-6,8-15,17

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/GB99/01594

	No:	Claims	1,7
Inventive step (IS)	Yes:	Claims	
	No:	Claims	2-6,8-15,17
Industrial applicability (IA)	Yes:	Claims	1-17
	No:	Claims	

2. Citations and explanations
see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:
see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:
see separate sheet

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/GB99/01594

The examination is being carried out on the **following application documents**:

Text for the Contracting States:

AT BE CH DE DK ES FI FR GB GR IT IE LI LU MC NL PT SE

Description, pages:

1-15 as originally filed

Claims, No.:

1-17 as originally filed

Drawings, sheets:

1/3-3/3 as originally filed

1. Reference is made to the following documents:

D1 : US-A-3772552

D2 : JP7115643 (publ. date 2/5/1995)

D2A : PATENT ABSTRACTS OF JAPAN, vol 1995, no. 8, &JP-A-7115643

D3 : WO-A-94/18801

The documents D2/D2A were not cited in the international search report.

2. **Claim 1**

- 2.1 This claim is drafted in such general terms as to lack novelty (Article 33(2) PCT) with respect to the disclosure of document D1. This document discloses a camera (see figure 1) with filter means (see figure 2, ref. F) arranged to attenuate the radiation reaching different spatial regions of the sensor to different extents, and decoding means (see figure 1, blocks 17 to 31) arranged to combine the

contributions to the output of the sensor from the different regions, to produce an output of extended dynamic range.

2.2 D2/D2A disclose an image pickup device having a wide dynamic range obtained by means of dark filters attached to some of the photoelements (see e.g. figure 3 of D2), in combination with a suitable processing system (see figures 2 and 4 of D2). Insofar as D2 does not disclose the combination of the signals provided by the clear pixels with those provided by the dark pixels, the subject-matter of claim 1 meets the requirements of Article 33(2) PCT.

2.3 However, the subject-matter of claim 1 does not meet the requirements of Article 33(3) PCT with respect to the combination of D2 with D3 (cited in the application), since it appears to be within the capabilities of the skilled person aware of the disclosures of these documents to use the two "exposures" provided by the sensor disclosed by D2 as inputs to the processing system disclosed by D3 (e.g. in figure 1, as inputs to blocks 20 and 22), thus coming to the subject-matter of claim 1.

This measure could be necessary, for example, to provide the processing system disclosed by D3 with two differently exposed, simultaneously taken pictures, so as to avoid "fuzziness" of the moving parts of the combined image due to the different times at which the component pictures are taken, said fuzziness being unavoidable otherwise (see also in D3, page 7, the passage from line 23 to line 31).

3. **Independent claim 17** fails with claim 1 since in the context of the present application the expression "expanded contrast" used in claim 17 is considered to be equivalent to "extended dynamic range" used in claim 1.
4. Further, for the above reason **claims 1 and 17** appear to relate effectively to the same subject-matter and to differ from each other only in respect of the terminology used for the features of that subject-matter. The aforementioned claims therefore lack conciseness (Article 6 PCT).
5. **Independent claim 16** does not meet the requirements of Article 6 PCT. The claim's wording is vague and unclear and leaves the reader in doubt as to the

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/GB99/01594

definition of the claimed subject-matter.

- 5.1 For the above reason, no examination of the subject-matter of this claim as to the requirements of Article 33 PCT can be carried out.

6. Dependent claims

- 6.1 The subject-matter of **claims 2 to 5, 9 and 14** is disclosed by D2 (see figure 3). The subject-matter of **claim 7** as appended to claim 1 is disclosed by D1 (see figure 2).
- 6.2 The additional features disclosed in the **remaining dependent claims** are considered to lie within the capabilities of the skilled person, and therefore they do not appear, at least for the time being, to add anything inventive to the subject-matter of the claims on which they depend.
- 6.3 Consequently, claim 7 does not meet the requirements of Article 33(2) PCT and the remaining claims do not meet the requirements of Article 33(3) PCT.
7. The independent claims are not in the two-part form in accordance with Rule 6.3(b) PCT, which in the present case would be appropriate, with those features known in combination from the prior art being placed in the preamble (Rule 6.3(b)(i) PCT) and with the remaining features being included in the characterising part (Rule 6.3(b)(ii) PCT).
8. The features of the claims are not provided with reference signs placed in parentheses (Rule 6.2(b) PCT).
9. Contrary to the requirements of Rule 5.1(a)(ii) PCT, the relevant background art disclosed in the documents D1 and D2 is not mentioned in the description, nor are these documents identified therein.

PCT

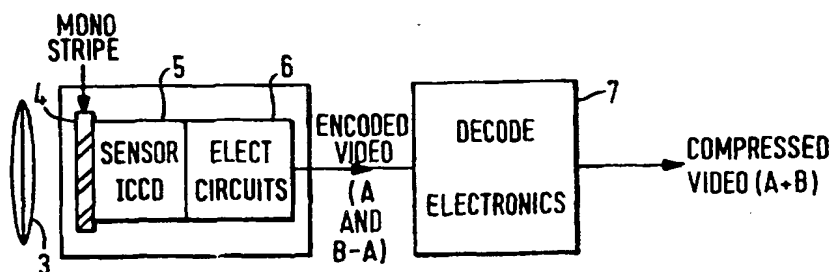
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International Bureau



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁷ : H04N 9/04, 5/20, 5/235		A1	(11) International Publication Number: WO 00/13421
			(43) International Publication Date: 9 March 2000 (09.03.00)
(21) International Application Number: PCT/GB99/01594		(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).	
(22) International Filing Date: 20 May 1999 (20.05.99)			
(30) Priority Data: 9818949.1 29 August 1998 (29.08.98) GB			
(71) Applicant (for all designated States except US): MARCONI ELECTRONIC SYSTEMS LIMITED [GB/GB]; The Grove, Warren Lane, Stanmore, Middlesex HA7 4LY (GB).			
(72) Inventor; and (75) Inventor/Applicant (for US only): SPENCER, Simon, Howard [GB/GB]; "Padarn", Hopping Jacks Lane, Danbury, Chelmsford, Essex (GB).			
(74) Agent: WATERS, Jeffrey; GEC Patent Dept., Waterhouse Lane, Chelmsford, Essex CM1 2QX (GB).			
		Published With international search report.	

(54) Title: CAMERAS



(57) Abstract

A camera comprises a sensor (5) such as a CCD or ICCD for receiving radiation representative of a scene, filter means (4) such as an arrangement of parallel neutral density stripes, arranged to attenuate the radiation reaching the sensor, and decoding electronics such as comb filters which decode the encoded video output of the sensor, (consisting of a high sensitivity image in which the radiation on the sensor is not attenuated and a low sensitivity image in which it is), to produce a compressed video image, from which the pattern of the filter means has been removed.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

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EE	Estonia						

CAMERAS

This invention relates to cameras.

The invention is especially concerned with the dynamic range of such cameras.

5 TV cameras such as TV broadcast cameras, CCTV, domestic video cameras, are provided with various servo mechanisms to enable satisfactory video signals to be produced from the imaging device, usually a CCD sensor, from a wide range of scene illuminations. The most common servo mechanism is an auto-iris, and in fact these can cope with a large dynamic range, particularly if a transparent plate with an attenuating
10 region or regions in the iris plane, denoted a spotted iris, are employed. The tendency has however been for the dynamic range between different scene illuminations (inter-scene) to be dealt with by electronic shuttering. This means that in scenes of lower illumination, the CCD or other sensor is exposed for a full field of 20 milliseconds (ms) but with higher illumination the imager is gated so as to be exposed for perhaps only 2
15 microseconds (μs).

Variations of illumination within a scene (intra-scene) present more problems. In a scene in which part is brightly illuminated and part is in shadow, if the region of shadow is of interest, then, if this signal is to occupy the full dynamic range of the
20 camera then the signals corresponding to the brightly illuminated region would greatly exceed the dynamic range of the camera, and therefore must either be clipped at peak level, thereby discarding the detail in the bright region, or compressed, thereby greatly

reducing the details in the dark region.

A multi-exposure technique has been demonstrated to overcome this problem (e.g. WO-A-94/18801). CCD sensors may be gated to take two exposures of the same scene with
5 different sensitivities e.g. 100:1 ratio. For example, alternate fields could be gated at 20 ms and 200 μ s. Combining these two fields produces a compressed picture. This technique is used for example when broadcasting sports events in which the action moves between one part of the ground in full sunlight and another part in shadow.

10 A drawback however is that the vertical resolution and temporal resolution are reduced with this technique.

Intra-scene dynamic ranges are of course decreased if the CCD sensor is used in conjunction with an image intensifier (ICCD), since the noise level is now increased. In
15 this case, imaging of scenes illuminated by starlight would be possible. Such an ICCD sensor has been disclosed in our patent application no. GB-A-2 318 012, in which coloured stripes were placed in front of the image intensifier, and processing electronics were used, to enable a monochrome sensor to produce a colour image.

20 If the double gating technique was extended to ICCDs as well as CCDs, there would be limitations about how fast the two exposures could be alternated. For example, if it was decided to expose twice within a field to reduce loss of vertical resolution, this might not be possible because of phosphor lag in the image intensifier. This is because an image intensifier has a photocathode on which an image is focussed, means such as a micro-

channel plate to multiply the number of electrons generated at the photocathode, and an anode on which the electrons impinge. The anode is coated with a phosphor to generate an optical image which is then picked up by a CCD. There is a limitation as to how fast the intensity of illumination of the phosphor can change.

5

The problem of double exposure with intensifiers could be solved by an arrangement of two intensifiers and a beam splitter passing, say, 90% intensity to one intensifier and 10% to the other. However, the cost and bulk of the camera would then increase, and the intensifier receiving the greater intensity of illumination would require replacement at more frequent intervals than the other.

10

The invention provides a camera comprising a sensor for receiving radiation representative of a scene, filter means arranged to attenuate the radiation reaching different spatial regions of the sensor to different extents, and decoding means arranged to combine the contributions to the output of the sensor from the different regions, to produce an output of extended dynamic range.

15

The invention permits the disadvantage of reduced vertical resolution and temporal resolution to be avoided without recourse to using two image intensifiers.

20

The attenuating regions of the filter are preferably arranged in stripes, preferably non-parallel to the lines of the sensor, preferably inclined at around 45° to the lines. Analogue comb filters are preferably used to decode the encoded video signal produced by the sensor.

The reference to filter means attenuating to a different extent includes total attenuation (opaque), zero attenuation (transparent), and any degree between opaque and transparent, and also includes attenuation by neutral density, by colour, or by polarisation.

- 5 The invention also provides a camera comprising a sensor for receiving radiation representative of a scene, filter means arranged to attenuate the radiation reaching different spatial regions of the sensor to different extents, and decoding means arranged to combine the contributions to the output of the sensor from the different regions, to produce an output of expanded contrast.

10

Cameras constructed in accordance with the invention will now be described in detail, by way of example, with reference to the accompanying drawings, in which:

- Figure 1 represents a subject it is desired to image, in which the subject has full contrast
15 and there are no highlights;

Figure 2 represents a scene which is actually to be imaged, wherein highlights present reduce the contrast on the subject to a low level;

- 20 Figure 3 represents a low sensitivity image of the scene of Figure 2;

Figure 4 represents a high sensitivity image of the scene of Figure 2;

Figure 5 represents a combination of the images of Figures 3 and 4;

Figure 6 is a block diagram of the camera;

Figure 7 represents a typical line of encoded video signal;

5 Figure 8 represents an optical filter bearing a stripe pattern overlying the sensor of the camera;

Figure 9 shows a filter to extract the peak level of the encoded video without the influence of the stripes;

10

Figure 10 shows a filter to extract a signal representative only of the stripes from the encoded video signal;

Figure 11 shows a circuit for demodulating the output representative of the stripe pattern;

15

Figure 12 is a block circuit diagram of the decode electronics to produce a compressed video signal; and

Figure 13 shows a portion of the sensor of the camera showing a number of lines of the sensor on which are superimposed the image of the optical filter together with a representation of the brightness variation produced on the video signal by the stripe pattern, any distortion of the image intensifier being ignored.

20

Referring to Figures 1 to 5, the aim is to produce a high contrast image of a subject 1 (Figure 1), when the subject is viewed in the presence of a bright light 2, which has the effect of reducing the contrast on the subject to a very low level. This is achieved by imaging the scene at two different sensitivities. Thus, a low sensitivity image (Figure 3) is produced, as well as a high sensitivity image (Figure 4), and the two are combined to produce a compressed image, which shows a full range of contrast in the subject, but which nevertheless shows detail in the light as well.

In accordance with the invention, the images of different sensitivities are produced simultaneously by means of an optical filter (Figures 8 and 13) which attenuates the radiation reaching various spatial regions of a sensor. Thus, referring to Figure 6, the TV camera of the invention comprises a lens 3 arranged to image a scene onto the image plane of an ICCD, at which the stripes of an optical filter 4 in contact with the ICCD, are in focus. Electrical circuit 6 processes the output of the ICCD, which is a video signal which simultaneously contains a low sensitivity and a high sensitivity representation of the scene being viewed. This encoded video signal is decoded in Decode Electronics 7 to produce a compressed image as in Figure 5.

Referring to Figures 8 and 13, the stripes are inclined and of such an density as to attenuate the incident radiation to 1% of incident intensity. The filter is clear between the stripes allowing 100% of incoming radiation through.

It will be appreciated that if the camera was imaged on a scene of uniform intensity, the video signal for each line would consist of an approximately sinusoidal oscillation,

corresponding to the pitch of the stripes 8 (Figures 8 and 13) in the scan direction, with the envelope of the peaks of the sinusoids being level (i.e. the peaks having the same amplitude) corresponding to light illumination through the transparent regions between the stripes 8, and the envelope of the troughs of the sinusoids also being level and
5 corresponding to light transmission through the stripes 8 themselves. Note that the video signal would have an approximately sinusoidal fluctuation, as represented in Figure 13, rather than the square wave shape of the optical filtering on the line of the imager, because of filtering in the processing circuits.

10 In the imaging of an actual scene, the envelopes of the peaks and troughs of the sinusoids for each line will not be level. The envelope of the peaks of the sinusoids (A) for any particular line will correspond to the variation of spatial intensity of the high sensitivity image of Figure 4, while the envelope of the troughs of the sinusoids (B) will correspond to the variation of spatial intensity of the low sensitivity image of Figure 3. Thus,
15 referring to Figure 2 and Figure 7, for one particular line, the part of the envelope A denoted by A^1 , corresponds to a high sensitivity image of the subject 1 in Figure 2 i.e. as seen through the transparent region between the stripes, whereas the part of the envelope A denoted by A^2 , corresponds to the image of the light as seen through the transparent regions. The envelope A^1 varies and contains details of the intensity of the subject, while
20 the part of the envelope A^2 is level since it has been clipped and therefore does not contain any detail of the light source 2. This corresponds to the image of Figure 4.

The part of the envelope B denoted B^1 corresponds to the low sensitivity view of the image 1 seen through the stripes, and is of such a low value as to barely be above the

noise threshold. The part of the envelope B^2 is a low sensitivity image of the light 2 and corresponds to the light imaged through the stripes 8. This does contain detail. This corresponds to the image of Figure 3.

- 5 The encoded video signal records the envelope of the peaks A and also the depth of the oscillation ($B - A$).

The decode electronics 7 is shown in more detail in Figure 12 and consists of analogue comb filters 9 and 10 and demodulator 11. The optical filter 4 is imaged on the CCD sensor, and Figure 13 shows, on an enlarged scale, a portion of the filter pattern superimposed on four lines of a field L_n to L_{n+3} of the CCD sensor, together with a representation of the sinusoidal variation of intensity produced on the lines of the video signal by the image of the optical filter.

- 15 Referring to Figure 13, the attenuating stripes (B for "black") alternate with non-attenuating stripes (W for "white"), but there is one more of one sort than the other. Such a situation applies in Figure 13, although of course in reality there would be many more pairs of attenuating and non-attenuating stripes. The reason for the extra stripe is so that the intensity modulation impressed on, say, line L_{n+1} will follow on continuously from that impressed on line L_n . In the example shown, the last section of line L_n is non-attenuating, so the first section of line L_{n+1} is attenuating.
- 20

The sensor operates in a progressive scan mode i.e. lines L_n , L_{n+1} , L_{n+2} , L_{n+3} are consecutive and there is no interlacing.

The decode electronic 7 operates in the following manner. In order to produce envelope A corresponding to the brightness of the high sensitivity image but with the stripe pattern removed, a transversal filter such as an analogue comb filter 9 sums the signals corresponding to adjacent lines e.g. L_n , L_{n+1} in analogue comb filter 9. This is achieved by adder 12 which sums the input directly received via link 14 and received via delay 13 which corresponds to one TV line ($64\mu s$). Referring to Figure 13, since the stripe pattern is in anti-phase on adjacent lines, the attenuation produced by this cancels, leaving only the brightness variation representative of the scene, which is reinforced since two lines are added. The output of comb filter 9 is thus output 2A.

10

The reason why the stripe pattern intensity is in anti-phase on successive lines is that the stripe pattern is inclined at 45° to the lines, and successive lines are spaced by half the wavelength of the stripe pattern.

15 In order to produce an output representing the difference between the modulation envelopes A and B, i.e. $|A - B|$, a transversal filter such as the comb filter in Figure 10 subtracts adjacent lines e.g. L_{n+3} , L_{n+2} to remove the overall brightness level of the scene whilst reinforcing the sinusoidal form of the stripe intensity modulation. Adjacent lines are subtracted at subtractor 15 by means of direct link 17 and delay 16 corresponding to one TV line ($64\mu s$). The output of this filter is the modulation corresponding to the depth of modulation of the sinusoids of the stripe pattern i.e. $|A - B|$. This signal is demodulated in diode detector 11 consisting of diode 18 and RC smoothing circuit 19, 20.

These two signals are combined at subtractor 21 (Figure 12). Since the output of the comb filter 9 is double the intensity of the scene, the resulting output from the decode electronic is the summation of the two envelopes A and B i.e. the required compressed image of Figure 5.

5

The sensitivity loss of having only half the sensor area fully sensitive is partly restored by the comb filtering benefits of noise i.e. 3db for single comb filter, 4.8db for a double filter.

10 Improved resolution can be obtained by the use of a third delay line 22 (delay $64\mu\text{s}$), shown dotted, the output of which is demodulated by a demodulator similar to that shown in Figure 11 but shown symbolically by diode 23. As an example, consider the arrival of line L_{n+2} at the input of comb filter 10. At the subtractor 15, line L_{n+1} is subtracted from it. The amplitude of the stripe pattern modulation is increased. At the diode 11, only
15 positive half cycles are passed i.e. the first, the third etc. At the same time, diode 23 is passing the positive cycles of the difference between lines L_{n+1} and L_n , this time only the second, fourth etc. half cycles. Thus, signal A-B is represented with increased resolution by combining signal A-B from diode detector 11 with signal (A-B)' from diode detector 23, so that there is signal present on each half cycle. Whereas the resolution of the low
20 sensitivity signal A - B has a bandwidth of approximately 1.8MHz, (the stripe pattern having a resolution of 3.5MHz), addition of the delayed stripe pattern (A - B)' gives a resolution of 3.5MHz.

With a typical CCD array of 600 x 600 pixels, the filter may consist of 300 neutral density stripes alternating with transparent regions of the same width as the stripes, subject to there being one more or less neutral density than transparent stripe across the length of each line. The stripes are arranged at the image plane of the ICCD in such a way that when their shadow is cast on the CCD array, the stripes are orientated at 45° to the lines of the CCD array L_n etc. It is critical that the lines are aligned with each other for the purposes of the comb filters, but manufacturing tolerances mean that the stripes will not be arranged at exactly 45° to the lines of the CCD, manufacturing tolerances might also dictate that there are slightly more or less than 300 stripes crossing the top or sides of the CCD array, and there may also be slight uncertainties in the crystal frequency of the camera which is used to generate the line frequencies etc. It is for this reason that, during manufacture, the delay lines 13, 16 and 22 are trimmed in order to get an exact one line delay of 64 μ s between adjacent lines, and this can be done using a oscilloscope on the output 21.

15

It will be appreciated that other inclinations of the stripes to the ICCD lines are possible, so long as they are not vertical, since in this case there would not be a phase difference between one line and the next for the stripe modulation pattern, and its effects could not be removed. It will merely be necessary to trim the delay lines 13, 16 and 22 so that the modulation patterns of consecutive lines is in anti-phase to each other. Also, it is not necessary for the stripes to alternate with equal widths of transparent areas. Other mark/space ratios are possible. Further, the stripe filter need not be positioned at the focal plane of the ICCD, it may be positioned anywhere in the path of radiation onto the CCD sensor e.g. using relay lenses, so long as it is in focus on the image plane and may

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in fact be formed directly on the CCD sensor. Further, it is not necessary for there to be the same number of stripes and transparent areas as there are lines of the sensor, there could be more or less stripes and alternating transparent regions than there are lines of the sensor.

5

In the embodiment described, the stripes only allow through 1% of light intensity. Of course, different densities are possible, and even the transparent region could be replaced by an attenuating region of different properties. In fact, opaque stripes i.e. 100% attenuation e.g. of aluminium, could be employed. Even though these stripes allow no light through at all, nevertheless there is a contribution to the output of the sensor, namely, due to noise $\left(\frac{1}{f}\right)$ particularly generated in the image intensifier but also in the CCD. This noise signal provides a black level reference which can be subtracted from the contribution to the output from the transparent regions, to compensate for temperature and $\left(\frac{1}{f}\right)$ noise.

15

Also, it is not necessary for the stripes to be of neutral density. They could be one particular colour e.g. blue, which would attenuate incandescent lights which radiate a large amount of red light.

20 Further, the stripes could be polarising, arranged to attenuate light of a particular polarisation. This could be a particular advantage in reducing reflections e.g. of light from a wet road surface.

Further, more than one set of stripes could be provided. For example, a second set of

different attenuating properties could be provided on the optical filter at a different angle to the lines of the sensor. Indeed, further sets of lines could be provided with different attenuating properties. In particular, a set of opaque stripes could be arranged with a set of 1% attenuating stripes. With one set of stripes, they could be inclined to the vertical of the raster as seen in Figure 13 at 22° , a second set could be arranged at -22° to the vertical, and a third set could be inclined at -45° to the vertical.

For example, a combination of stripes of neutral density, coloured (e.g. dark blue) and opaque could be used. The benefit of the invention (picture compression and extended dynamic range) would be both spectrally and scene responsive.

Further, one or more sets of stripes, provided to extend the dynamic range of the sensor in accordance with the invention, could be combined with coloured stripes as described in our earlier patent application no. 2 318 012 to produce a colour or pseudo colour output from a monochrome sensor. Indeed, two sets of coloured stripes could be provided; a first set of one attenuation to produce the colour output, and a second set of greater attenuation (the same colour but greater density) to extend the dynamic range. These could be set at different angles to the first set.

Variations may be made on the encoding (stripe patterns) and decoding to produce the signals A , $A - B$, $(A - B)'$. There are benefits to be gained by using more sophisticated filtering in the decode electronics block 7. For example, double delay filters or triple delay filters may be used.

The regular pitch of the stripes gives the option of demodulation of the encoded video by the use of a circuit tuned to the frequency of the stripes.

In the described embodiment using ICCD, the image intensifier used produces a distortion of only ½% at the CCD sensor. However, there are other image intensifiers which produce a much greater geometric distortion e.g. 10%, in which case the stripe pattern of Figure 13 would be distorted by the image intensifier. Another alternative which would be useful in this case, would be for the decode electronics to use a memory map relying on stored signals to relate the pixels of the CCD sensor to the (distorted) stripe pattern falling on the CCD sensor, for example as described in our prior patent application no. 2 318 012. Indeed, if a memory map was used, the attenuating regions of the filter could be in any arrangement desired, not necessarily a stripe pattern.

As another alternative, it will be possible to modify the delay network to accommodate geometry distortion by providing a voltage variable delay having as its input a signal related to the geometric distortion of the ICCD. Non-linear tuned circuits e.g. level and/or frequency adaptive could be used e.g. to remove a low level stripe pattern.

The stripes may be placed in contact with the ICCD or a relay lens may be used to project their image onto the image plane of the ICCD.

In the embodiments referred to above, the imager is an ICCD. The ICCD sensor comprises as is well known a CCD array coupled e.g. by optical fibres to the phosphors on the output surface of an image intensifier. The striped pattern may be cemented to the

front surface of the intensifier, possibly using a fibre optic coupling. However, the invention is applicable also to CCD sensors which are not intensified. Further the invention is applicable to monochrome or colour sensors. However, in fact a wide variety of imagers may be used such as a CMOS imager, a tube such as a vidicon or orthicon, sensors active in the UV region may be used, e.g. visible near infra-red or far infra-red. The invention has been described in relative to progressive scanning, but is also applicable to interlace scan.

Furthermore the sensor may be a non-imaging sensor e.g. for an infra-red intruder alarm. Or the invention is applicable to optically-coupled thermal cameras in which the thermal signal is used to vary the intensity of light on a sensor e.g. by varying the polarising angle in a transducer.

The cameras described above are used for high contrast scenes where compression is desirable. Some scenes, of lesser contrast, will benefit from the invention as well. Very low contrast scenes, such as "misty" viewing conditions, will not show any benefit from the cameras. A small change to the cameras described above can accommodate very low contrast scenes. When the subtractor 15 in Figure 12 is changed to be positive i.e. an adder, the camera becomes an expander of contrast. Some imaging sensors have a non-linear compression response (e.g. specially fabricated CCD devices). These special devices could be converted to a linear response by using the expansion improvement. In fact, the cameras described above could be provided with a switch to enable the contrast expander option to be selected as desired.

CLAIMS

1. A camera comprising a sensor for receiving radiation representative of a scene, filter means arranged to attenuate the radiation reaching different spatial regions of the sensor to different extents, and decoding means arranged to combine the contributions to the output of the sensor from the different regions, to produce an output of extended dynamic range.
2. A camera as claimed in Claim 1, in which the sensor is arranged to produce an output representative of lines of the image, and the filter means comprises stripes orientated so that the lines of the stripes are inclined to the lines of the image.
3. A camera as claimed in Claim 2, in which the stripes are inclined at an angle within the range $\pm(45^\circ \text{ to } 80^\circ)$ to the lines of the image.
4. A camera as claimed in Claim 3, in which the stripes are at approximately $\pm 45^\circ$ to the lines of the image.
5. A camera as claimed in any one of Claims 1 to 4, in which the stripes are neutral density stripes.
6. A camera as claimed in any one of Claims 1 to 4, in which the stripes are opaque.
7. A camera as claimed in any one of Claims 1 to 4, in which the stripes are

coloured.

8. A camera as claimed in any one of Claims 1 to 4, in which the stripes are polarising.

9. A camera as claimed in any one of Claims 2 to 8, in which the regions between the stripes are transparent.

10. A camera as claimed in any one of Claims 1 to 9, in which there are two or more sets of stripes, each have different attenuating properties, inclined at different angles to the lines of the sensor.

11. A camera as claimed in any one of Claims 1 to 10, in which the decoding means is arranged to combine successive lines of the image to reinforce the scene and cancel the contribution to the intensity of the stripes.

12. A camera as claimed in any one of Claims 1 to 11, in which the decoding means is arranged to combine successive lines of the image to cancel the contribution to the intensity of the scene and reinforce that of the stripes.

13. A camera as claimed in Claim 11 or Claim 12, in which the decoding means comprises one or more comb filters.

14. A camera as claimed in any one of Claims 1 to 13, in which the sensor is a CCD.

15. A camera as claimed in any one of Claims 1 to 14, in which the sensor includes an image intensifier.
16. A camera substantially as herein described with reference to and as shown in the accompanying drawings.
17. A camera comprising a sensor for receiving radiation representative of a scene, filter means arranged to attenuate the radiation reaching different spatial regions of the sensor to different extents, and decoding means arranged to combine the contributions to the output of the sensor from the different regions, to produce an output of expanded contrast.

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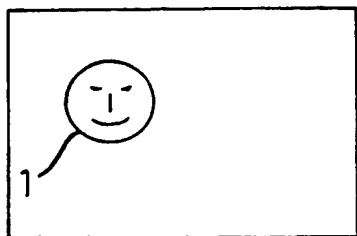


FIG. 1

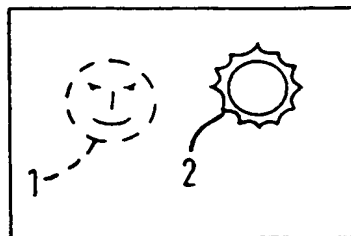


FIG. 2

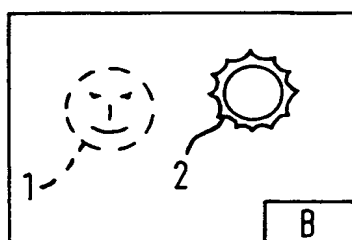


FIG. 3

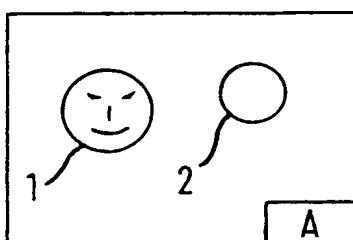


FIG. 4

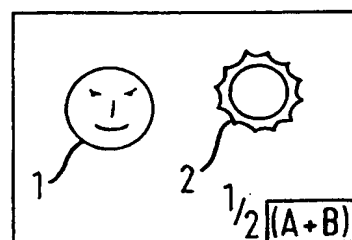


FIG. 5

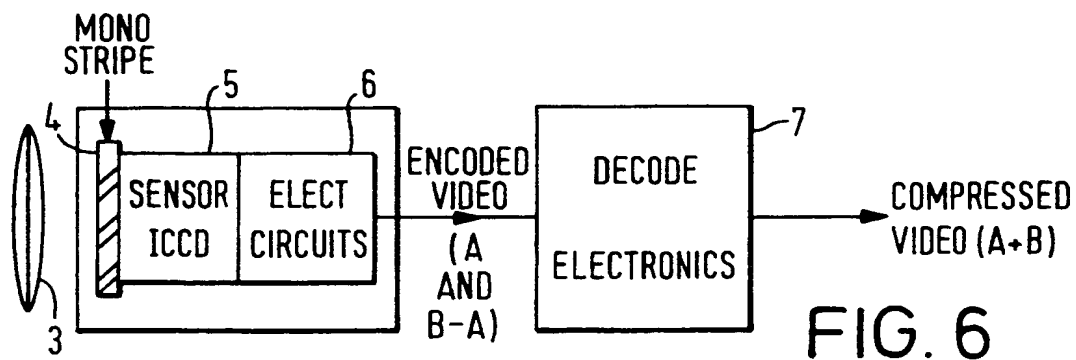


FIG. 6

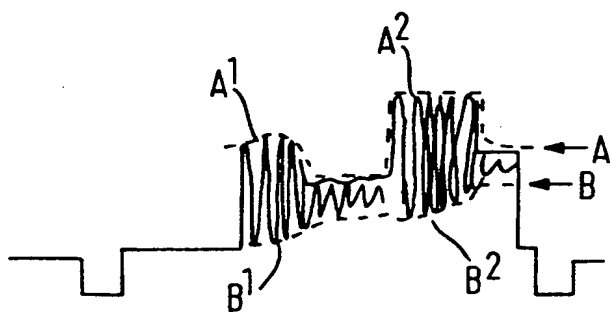


FIG. 7

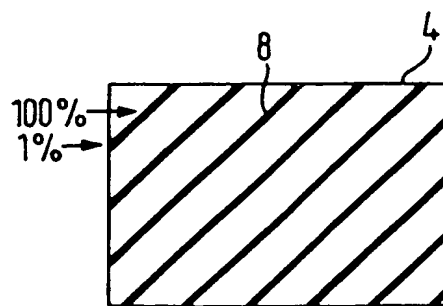
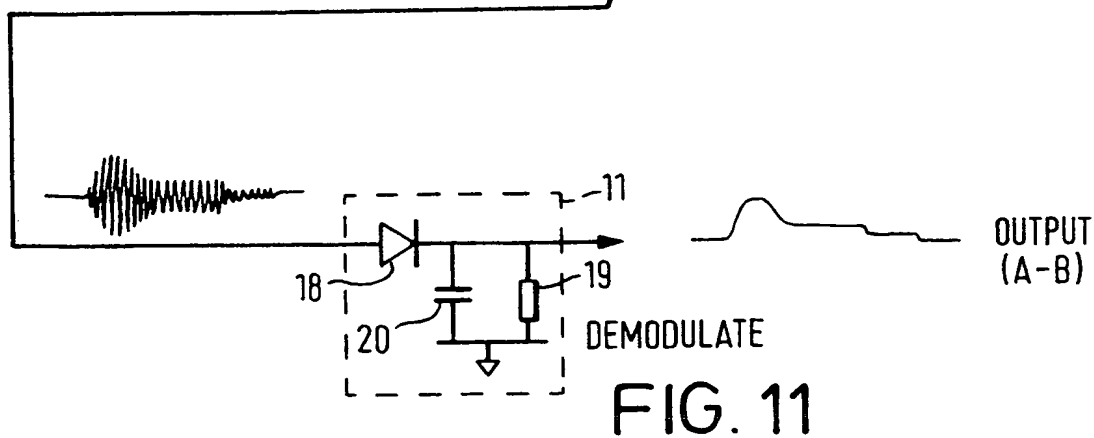
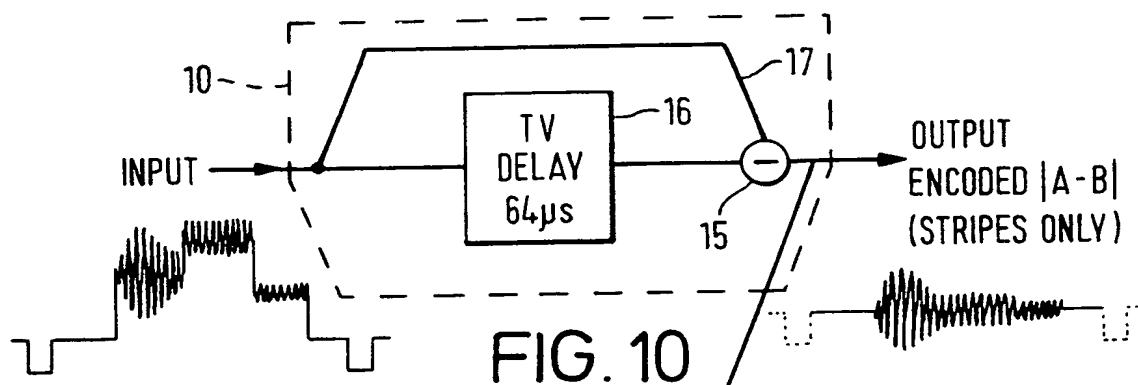
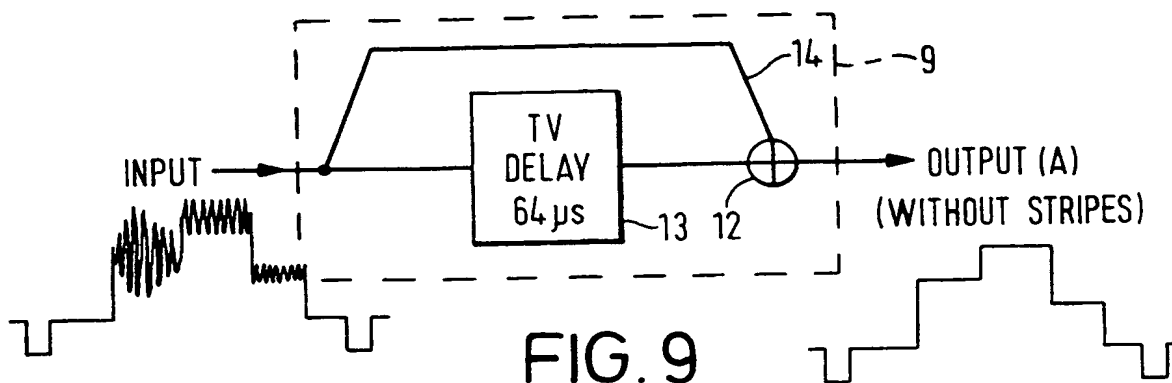
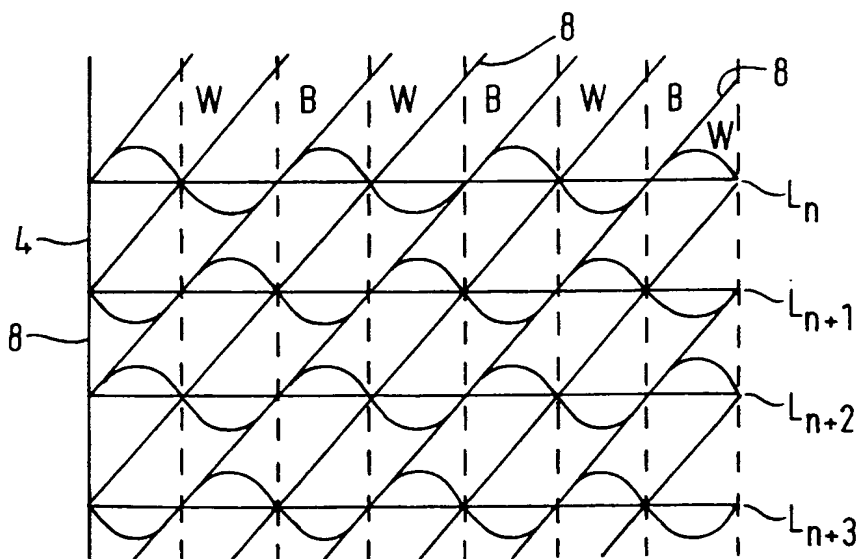
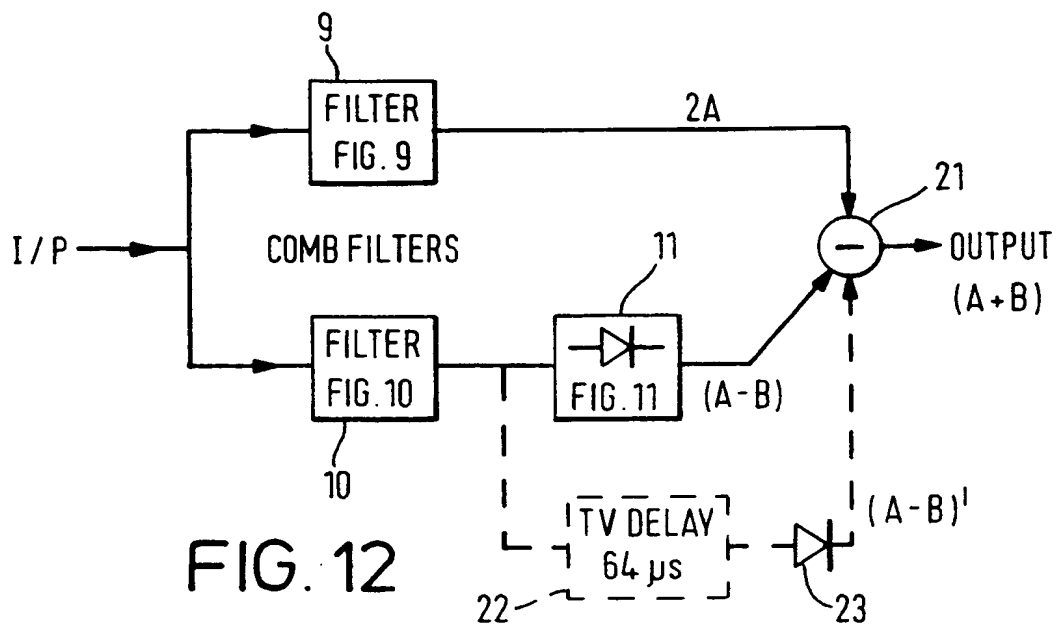


FIG. 8

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INTERNATIONAL SEARCH REPORT

national Application No

PCT/GB 99/01594

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 H04N9/04 H04N5/20 H04N5/235

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 H04N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 3 772 552 A (KUBOTA Y) 13 November 1973 (1973-11-13) column 3, line 18 - column 7, line 15 ---	1-4, 6, 7, 9, 11, 13-15, 17
Y	PATENT ABSTRACTS OF JAPAN vol. 095, no. 008, 29 September 1995 (1995-09-29) & JP 07 131708 A (CANON INC), 19 May 1995 (1995-05-19) abstract & US 5 801 773 A ---	1, 14, 17
Y	GB 2 318 012 A (MARCONI GEC LTD) 8 April 1998 (1998-04-08) cited in the application page 9, line 3 - page 20 ---	2-4, 6, 7, 9, 11, 13, 15
	-/--	

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

23 July 1999

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INTERNATIONAL SEARCH REPORT

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>WO 94 18801 A (SIGHT INC I) 18 August 1994 (1994-08-18) page 4, line 10 - page 32 -----</p>	1-17

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/GB 99/01594

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			JP 10200905	A	31-07-1998
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